

Ten Years of Progress in Improving Agricultural Phosphorus Management: A Case Study of the State of Delaware, USA.

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Introduction

Nonpoint phosphorus (P) pollution of Delaware's fresh and coastal surface waters has been a recognized ecological problem for more than 30 years. Concerns reached a peak in 1997 when algal blooms (e.g., *Pfiesteria piscicida*) in bays and rivers were linked to major fishkills, human health problems, and agricultural nonpoint nutrient pollution. Land application of manures generated by the state's large and geographically concentrated poultry industry was regularly cited as a major contributing factor to water quality degradation. State and federal agencies responded by bringing together scientists, farmers, poultry integrating companies, environmental groups, and many others to devise a strategy that would mitigate the impacts of nutrients on surface and shallow ground waters. Following heated debates and often contentious discussions on the scientific principles of nutrient cycling, transport, and ecological impact, the Delaware Nutrient Management Act was passed in 1999. This law established a statewide nutrient management commission (DNMC) to develop science-based approaches to manage nutrients in a manner that could sustain agricultural productivity and improve water quality. Ten years after the original incidents that sparked the passage of this law, and similar laws in other U.S. states, considerable progress has been made in agricultural nutrient management, particularly with respect to P. In this presentation, we review and critically analyze the impacts of the process used in Delaware for the past decade to develop mitigation options for nonpoint P pollution. We also look to the future and assess new opportunities to further improve P management and restore the ecological quality of Delaware's waters.

Advances in Nutrient Management in Delaware from 1997 to 2007

The establishment of the DNMC effectively institutionalized the process of statewide nutrient management planning and has led to the systematic development of numerous programs that are improving agricultural P management. One of the key benefits of creating the DNMC was the provision of a formal structure for ongoing interactions between University of Delaware (UD) scientists and extension specialists, federal and state technical agencies, environmental regulators, and the agricultural community. This continuity in cooperative planning and action has been central to the progress made in nutrient management Delaware in the past 10 years.

The composition of the DNMC¹, which combines farmers, environmentalists, and technical experts in nutrient management, has also greatly facilitated cooperative discussions about causes and solutions to Delaware's nutrient management and water quality problems. At the same time, scientists and technical experts in the USDA Natural Resources Conservation Service (NRCS) and local conservation districts worked hand-in-hand with the DNMC to develop cost-effective solutions that are leading to more efficient "P-based" nutrient management by agriculture. Some of the more important actions that have occurred in the past 10 years include:

Nutrient management education and certification: To date, ~2000 farmers and other nutrient users have participated in formal nutrient management training and received certification as "nutrient generators", "private nutrient handlers", "commercial nutrient handlers", or "nutrient consultants". Continuing education is also required and in 2006 alone, Delaware Cooperative Extension specialists offered 60 training programs for > 2000 individuals.

Nutrient management planning: Any operation that applies nutrients to > 4 ha of land or manages > 8 animal equivalent units must become certified in nutrient management, develop and implement an approved nutrient management plan and submit an annual report to the DNMC. Nutrient management plans are now in place for ~185,000 ha, or about 99% of Delaware's agricultural crop land.

Manure nutrient relocation programs: A DNMC supported manure relocation program was established in 2001 to help farmers with manure surpluses transport excess manure to farms in need of manure nutrients or to alternative uses. About 400,000 tons of poultry manure has been relocated to date; key outlets include a plant that produces pelletized manure-based fertilizer and regional mushroom farms.

Risk assessment protocols for nonpoint P pollution: Research and on-farm field assessments conducted by University of Delaware scientists led to the development, and adoption by the DNMC, of (i) soil test criteria to identify "high P" soils where fertilizers and manures must be applied at crop P removal rates; and (ii) a Phosphorus Site Index (PSI) used to characterize the risk of P loss to water based on site characteristics, hydrology, and fertilizer/manure P management practices. Farmers have the option of using the soil test P threshold or a PSI to guide P management of manures and fertilizers on their farms.

¹ The DNMC is composed of 8 members of the agricultural community (representatives of grain crop producers, animal producers, vegetable growers, commercial nurseries, and golf/lawn care industry), 2 representatives from environmental advocacy groups, a representative of commercial nutrient applicators, a nutrient consultant, a public citizen, the director of the state Soil & Water Conservation division. Ex-officio members include the Secretary of the Department of Natural Resources & Environmental Control and the Secretary of the Department of Agriculture. See <http://dda.delaware.gov/nutrients/index.shtml> for more details and publications on the DNMC.

DNMC memoranda of understanding with poultry industry: All poultry integrating companies signed a formal agreement in 2001 to foster cooperative efforts to improve nutrient management, leading to a number of successful actions: (i) the improved management of P in poultry feed, which, by use of phytase enzymes and reductions in mineral P, has reduced manure P content by ~30%; (ii) environmental stewardship programs for poultry farmers; (iii) certification and education programs completed by poultry industry employees and poultry farmers; and (v) ongoing, industry-wide evaluations of alternative uses for excess poultry litter.

Environmental permitting for certain animal operations: The DNMC has worked to improve nutrient management on Concentrated Animal Feeding Operations (CAFOs) that are required by the U.S. Clean Water Act (1972) to have permits designed to protect surface water quality. An agreement between the DNMC and the US Environmental Protection Agency followed numerous public meetings where policy decisions were debated and discussed. The agreement authorizes the DNMC to implement regulations and handle initial enforcement efforts for CAFOs in Delaware.

Research and demonstration projects support best management practices (BMPs): Years of research conducted by UD scientists and colleagues led to a wide range of cost-effective nutrient management BMPs. The DNMC identified and published criteria for 56 BMPs designed to minimize nonpoint nutrient pollution ("Nutrient Best Management Practices: Today's Agriculture: A Responsible Legacy"). The DNMC also funds research and demonstration projects each year to aid in the development of science-based environmental policies.

Nutrient surpluses have been reduced: Excess nutrients are common in areas dominated by animal-based agriculture and often lead to nonpoint nutrient pollution of ground and surface waters. Recent analyses of trends in statewide nutrient balances have shown that the actions taken by the DNMC, the University of Delaware, NRCS, and Delaware's agricultural community have significantly reduced nutrient surpluses. For example, estimated statewide P surpluses decreased by 42%, from 25 kg P ha⁻¹ to 14 kg P ha⁻¹, between 1997 and 2005. Nitrogen surpluses were also reduced, from 62 to 35 kg N ha⁻¹. Major contributing factors were reductions in fertilizer use, likely due to increased nutrient management planning, and improved P feeding practices by Delaware's poultry industry.

In conclusion, the concerted efforts of a diverse group of individuals, agencies, and organizations committed to sustaining agriculture and protecting water quality, have markedly improved agricultural nutrient management in Delaware in a relatively short period of time. Significant challenges do remain, but the partnerships built in the past 10 years between scientists, policy-makers, technical and regulatory agencies, and the agricultural community provides a solid foundation for continued progress.